JAPAN

EDICT OF GOVERNMENT

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JIS B 9700-1 (2004) (English): Safety of machinery -- Basic concepts, general principles for design -- Part 1: Basic terminology, methodology

ISO INSIDE

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The citizens of a nation must honor the laws of the land.

Fukuzawa Yukichi

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JIS

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS B 9700-1 : 2004

(ISO 12100-1 : 2003)
(JMF)

Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology

ICS 01.040.13; 13.110
Reference number : JIS B 9700-1 : 2004 (E)

Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Health, Labour and Welfare, and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from the Japan Machinery Federation (JMF) with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

This Standard has been made based on **ISO 12100-1**:2003 *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology* for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

JIS B 9700 consists of the following 2 parts under the general title *"Safety of machinery — Basic concepts, general principles for design"* :

Part 1: Basic terminology, methodology

Part 2: Technical principles.

A set of standards for safety of machinery has the following structure:

- type-A standards (basic safety standard) giving basic concepts, principles for design, and general aspects that can be applied to all machinery;
- type-B standards (generic safety standards) dealing with one safety aspect or one type of safeguard that can be used across a wide range of machinery:
  - type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);
  - type-B2 standards on safeguards (e.g. two-hand controls, interlocking devices, pressure sensitive devices, guards);
- type-C standards (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This Standard is a type-A standard.

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Standards Board
Technical Committee on Industrial Machinery

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In the event of any doubts arising as to the contents, the original JIS is to be the final authority.

Contents

JAPANESE INDUSTRIAL STANDARD

JIS B 9700-1 : 2004
(ISO 12100-1 : 2003)

Safety of machinery — Basic concepts, general principles for design — Part 1 : Basic terminology, methodology

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 12100-1** *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology* published in 2003 without modifying the technical contents.

Portions underlined with dots are the matters not stated in the original International Standard.

The primary purpose of **JIS B 9700** is to provide designers with an overall framework and guidance to enable them to produce machines that are safe for their intended use. It also provides a strategy for standard makers.

The concept of safety of machinery considers the ability of a machine to perform its intended function(s) during its lifecycle where risk has been adequately reduced.

The subject of numerous clauses or subclauses of this Standard is also dealt with, in a more detailed manner, in other type-A or B standards.

When a type-C standard deviates from one or more provisions dealt with by Part 2 of this Standard or by a type-B standard, the type-C standard takes precedence.

1 Scope This Standard defines basic terminology and methodology used in achieving safety of machinery.

The provisions stated in this Standard are intended to be used by the designer.

This Standard does not deal with damage to domestic animals, property or the environment.

NOTE : This International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology methodology* (IDT)

2 Normative references The following standards contain provision which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of publication or the year of coming into effect is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply. The normative references without the indication of the year of publication or the year of coming into effect apply only to the most recent edition (including amendments).

JIS B 9700-2:2004 *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

NOTE : **ISO 12100-2**:2003 *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles* is identical with the said standard.

JIS B 9702:2000 *Safety of machinery — Principles for risk assessment*

NOTE : **ISO 14121**:1999 *Safety of machinery — Principles for risk assessment* is identical with the said standard.

JIS B 9703 *Safety of machinery — Emergency stop — Principles for design*

NOTE : **ISO 13850** *Safety of machinery — Emergency stop — Principles for design* is identical with the said standard.

JIS B 9704-2 *Safety of machinery — Electro sensitive protective equipment — Part 2: Particular requirements for equipment using active opto electronic protective devices (AOPDs)*

NOTE : **ISO 61496-2** *Safety of machinery — Electro-sensitive protective equipment (ESPE) — Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)* is identical with the said standard.

JIS B 9960-1:1999 *Safety of machinery — Electrical equipments of machines — Part 1: General requirements*

NOTE : **ISO 60204-1**:1997 *Safety of machinery — Electrical equipments of machines — Part 1: General requirements* is equivalent to the said standard.

ISO 13851 *Safety of machinery 'Two-hand control devices' functional aspects and design principles*

ISO 14118:2000 *Safety of machinery — Prevention of unexpected start-up*

ISO 14119 *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 14120 *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 11689 *Acoustics — Procedure for the comparison of noise-emission data for machinery and equipment*

3 Terms and definitions For the purposes of **JIS B 9700-1** and **-2**, the following terms and definitions apply.

3.1 machinery, machine assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material. The terms "machinery" and "machine" also cover an assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole.

NOTE : Annex A provides a general schematic representation of a machine.

3.2 reliability (of a machine) ability of a machine or its components or equipment, to perform a required function under specified conditions and for a given period of time without failing

3.3 maintainability (of a machine) ability of a machine to be maintained in a state which enables it to fulfil its function under conditions of "intended use", or restored into such a state, the necessary actions (maintenance) being carried out according to specified practices and using specified means

3.4 usability (of a machine) ability of a machine to be easily used thanks to, among others, properties or characteristics that enable its function(s) to be easily understood.

3.5 harm physical injury or damage to health

3.6 hazard potential source of harm

NOTES 1 The term "hazard" can be qualified in order to define its origin (e.g. mechanical hazard, electrical hazard) or the nature of the potential harm (e.g. electric shock hazard, cutting hazard, toxic hazard, fire hazard).

2 The hazard envisaged in this definition:

- either is permanently present during the "intended use" of the machine (e.g. motion of hazardous moving elements, electric arc during a welding phase, unhealthy posture, noise emission, high temperature);
- or may appear unexpectedly (e.g. explosion, crushing hazard as a consequence of an unintended / unexpected start-up, ejection as a consequence of a breakage, fall as a consequence of acceleration / deceleration).

3.7 relevant hazard hazard which is identified as being present as or associated with the machine

NOTE : A relevant hazard is identified as the result of one step of the process described in **JIS B 9702**.

3.8 significant hazard hazard which has been identified as relevant and which requires specific action by the designer to eliminate or to reduce the risk according to the risk assessment

3.9 hazardous situation circumstance in which a person is exposed to at least one hazard. The exposure can immediately or over a period of time result in harm

3.10 hazard zone, danger zone any space within and/or around machinery in which a person can be exposed to a hazard

3.11 risk combination of the probability of occurrence of harm and the severity of that harm

3.12 residual risk risk remaining after protective measures have been taken (see also figure 1)

NOTE : This standard distinguishes:

- the residual risk after protective measures have been taken by the designer;
- the residual risk after all protective measures have been implemented

3.13 risk assessment overall process comprising a risk analysis and a risk evaluation

3.14 risk analysis combination of the specification of the limits of the machine, hazard identification and risk estimation

3.15 risk estimation defining likely severity of harm and probability of its occurrence

3.16 risk evaluation judgement, on the basis of risk analysis, of whether the risk reduction objectives have been achieved

3.17 adequate risk reduction risk reduction at least in accordance with the legal requirements under consideration of the current state of the art

NOTE : Criteria for determining when adequate risk reduction is achieved are given in **5.5**.

3.18 protective measure measure intended to achieve risk reduction, implemented (see figure 1.) :

- by the designer (inherently safe design, safeguarding and complementary protective measures, information for use) and
- by the user (organization: safe working procedures, supervision, permit-to-work systems; provision and use of additional safeguards; use of personal protective equipment; training).

3.19 inherently safe design measure protective measure which either eliminates hazards or reduces the risks associated with hazards by changing the design or operating characteristics of the machine without the use of guards or protective devices

NOTE : **JIS B 9700-2**:2004, clause **4**, deals with risk reduction by inherently safe design measures.

3.20 safeguarding protective measure using safeguards to protect persons from the hazards which cannot reasonably be eliminated or from the risks which cannot be sufficiently reduced by inherently safe design measures

NOTE : **JIS B 9700-2**:2004, clause **5**, deals with safeguarding.

3.21 information for use protective measure consisting of communication links (e.g. texts, words, signs, signals, symbols, diagrams) used separately or in combination, to convey information to the user

NOTE : **JIS B 9700-2**:2004, clause **6**, deals with information for use.

3.22 "intended use" of a machine use of a machine in accordance with the information provided in the instructions for use

3.23 reasonably foreseeable misuse use of a machine in a way not intended by the designer, but which may result from readily predictable human behaviour

3.24 safeguard guard or protective device

3.25 guard physical barrier, designed as part of the machine, to provide protection

NOTES 1 A guard may act:

- alone; it is then only effective when it is "closed" for a movable guard or "securely held in place" for a fixed guard;
- in conjunction with an interlocking device with or without guard locking; in this case, protection is ensured whatever the position of the guard

2 Depending on its design, a guard may be called e.g. casing, shield, cover, screen, door, enclosing guard.

3 See **JIS B 9700-2**:2004, **5.3.2**, and **ISO 14120** for types of guards and their requirements.

3.25.1 fixed guard guard affixed in such a manner (e.g. by screws, nuts, welding) that it can only be opened or removed by the used of tools or destruction of the affixing means

3.25.2 movable guard guard which can be opened without the use of tools

3.25.3 adjustable guard fixed or movable guard which is adjustable as a whole or which incorporates adjustable part(s). The adjustment remains fixed during a particular operation

3.25.4 interlocking guard guard associated with an interlocking device so that, together with the control system of the machine, the following functions are performed:

- the hazardous machine functions "covered" by the guard cannot operate until the guard is closed;
- if the guard is opened while hazardous machine functions are operating, a stop command is given;
- when the guard is closed, the hazardous machine functions "covered" by the guard can operate. The closure of the guard does not by itself start the hazardous machine functions

NOTE : **ISO 14119** gives detailed provisions.

3.25.5 interlocking guard with guard locking guard associated with an interlocking device and a guard locking device so that, together with the control system of the machine, the following functions are performed:

- the hazardous machine functions "covered" by the guard cannot operate until the guard is closed and locked;

- the guard remains closed and locked until the risk due to the hazardous machine functions "covered" by the guard has disappeared;
- when the guard is closed and locked, the hazardous machine functions "covered" by the guard can operate. The closure and locking of the guard do not by themselves start the hazardous machine functions

NOTE : **ISO 14119** gives detailed provisions.

3.25.6 interlocking guard with a start function, control guard special form of an interlocking guard which, once it has reached its closed position, gives a command to initiate the hazardous machine function(s) without the use of a separate start control

NOTE : **JIS B 9700-2**:2004, **5.3.2.5**, gives detailed provisions regarding the conditions of use.

3.26 protective device safeguard other than a guard

NOTE : Examples of protective devices are given in **3.26.1** to **3.26.9**.

3.26.1 interlocking device, interlock mechanical, electrical or other type of device, the purpose of which is to prevent the operation of hazardous machine functions under specified conditions (generally as long as a guard is not closed)

3.26.2 enabling device additional manually operated device used in conjunction with a start control and which, when continuously actuated, allows a machine to function

NOTE : **JIS B 9960-1**:1999, **9.2.5.8**, gives detailed provisions on enabling devices.

3.26.3 hold-to-run control device control device which initiates and maintains hazardous machine functions only as long as the manual control (actuator) is actuated

3.26.4 two-hand control device control device which requires at least simultaneous actuation by both hands in order to initiate and to maintain hazardous machine functions, thus providing a protective measure only for the person who actuates it

NOTE : **ISO 13851** gives detailed provisions.

3.26.5 sensitive protective equipment (SPE) equipment for detecting persons or parts of persons which generates an appropriate signal to the control system to reduce risk to the persons detected. The signal may be generated when a person or part of a person goes beyond a predetermined limit — e.g. enters a hazard zone — (tripping) or while a person is detected in a predetermined zone (presence sensing), or in both cases

3.26.6 active opto-electronic protective device (AOPD) device whose sensing function is performed by opto-electronic emitting and receiving elements detecting the interruption of optical radiation, generated within the device, by an opaque object present in the specified detection zone

NOTE : **JIS B 9704-2** gives detailed provisions.

3.26.7 mechanical restraint device device which introduces into a mechanism a mechanical obstacle (e.g. wedge, spindle, strut, scotch) which, by virtue of its own strength, can prevent any hazardous movement

3.26.8 limiting device device which prevents a machine or hazardous machine condition(s) from exceeding a designed limit (e.g. space limit, pressure limit, load moment limit)

3.26.9 limited movement control device control device, a single actuation of which, together with the control system of the machine, permits only a limited amount of travel of a machine element

3.27 impeding device any physical obstacle — e.g. low barrier, rail — which, without totally preventing access to a hazard zone, reduces the probability of access to this zone by offering an obstruction to free access

3.28 safety function function of a machine whose failure can result in an immediate increase of the risk(s)

3.29 unexpected start-up, unintended start-up any start-up which, because of its unexpected nature, generates a hazard. This can be caused by, e.g.:

- a start command which is the result of a failure in, or an external influence on, the control system;
- a start command generated by inopportune action on a start control or other parts of the machine as, e.g., a sensor or a power control element;
- restoration of the power supply after an interruption;
- external / internal influences (e.g. gravity, wind, self-ignition in internal combustion engines) on parts of the machine

NOTE : Machine start-up during normal sequence of an automatic cycle is not "unintended", but can be considered to be "unexpected" from the point of view of the operator. Prevention of accidents in this case involves the use of safeguarding measures (see **JIS B 9700-2**:2004, clause **5**).

[from **ISO 14118**:2000, **3.2**]

3.30 failure to danger any malfunction in the machinery, or in its power supply, that increases the risk

3.31 fault the state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

NOTES 1 A fault is often the result of a failure of the item itself, but may exist without prior failure (see **IEV 191-15-01** of **IEC 60050**).

2 In practice, the terms "fault" and "failure" are often used synonymously.

3.32 failure the termination of the ability of an item to perform a required function

NOTES 1 After failure, the item has a fault.

2 "Failure" is an event, as distinguished from "fault", which is a state.

3 The concept as defined does not apply to items consisting of software only.

[IEV 191-04-01 of IEC 60050]

3.33 common cause failures failures of different items, resulting from a single event, where these failures are not consequences of each other

NOTE : Common cause failures should not be confused with common mode failures.

[IEV 191-04-23 of IEC 60050]

3.34 common mode failures failures of items characterized by the same fault mode

NOTE : Common mode failures should not be confused with common cause failures, as the common mode failures may result from different causes.

[IEV 191-04-24 of IEC 60050]

3.35 emergency situation hazardous situation needing to be urgently ended or averted

NOTE : An emergency situation may arise :

- during normal operation of the machine (e.g. due to human interaction, or as a result from external influences);
- as a consequence of a malfunction or a failure of any part of the machine.

3.36 emergency operation all actions and functions intended to end or avert an emergency situation

3.37 emergency stop function which is intended:

- to avert arising or to reduce existing hazards to persons, damage to machinery or to work in progress;
- to be initiated by a single human action

NOTE : **JIS B 9703** gives detailed provisions.

3.38 emission value numerical value quantifying an emission generated by a machine (e.g. noise, vibration, hazardous substances, radiation)

NOTES 1 Emission values are part of the information on the properties of a machine and are used as a basis for risk assessment.

2 The term "emission value" should not be confused with "exposure value" which quantifies the exposure of persons to emissions when the machine is in use. Exposure values can be estimated using the emission values.

3 Emission values are preferably measured and their associated uncertainties determined by means of standardized methods, e.g. to allow comparison between similar machines.

3.39 comparative emission data set of emission values of similar machines collected for the purpose of comparison

NOTE : For noise comparison, see **ISO 11689**.

4 Hazards to be taken into account when designing machinery

4.1 General The purpose of this clause is to provide a description of basic hazards with a view to assisting the designer in identifying the relevant and significant hazards which the machine under consideration can generate and the hazards associated with the environment in which the machine is intended to be used (see also **5.3**).

NOTE : See **JIS B 9702**:2000, annex A for a more detailed list of possible hazards and hazardous situations related to machinery.

4.2 Mechanical hazard

4.2.1 Mechanical hazards associated with a machine, machine parts or surfaces, tools workpieces, loads, or projected solid or fluid materials can result in:

- crushing;
- shearing;
- cutting or severing;
- entanglement;
- drawing-in or trapping;
- impact;
- stabbing or puncture;
- friction or abrasion;
- high pressure fluid injection (ejection hazard).

4.2.2 The mechanical hazards which can be generated by a machine, machine parts (including work material holding mechanisms), workpieces or loads are conditioned, among other factors, by:

- shape (cutting elements, sharp edges, angular parts, even if they are motionless) ;
- relative location, which can create crushing, shearing, entanglement zones when elements are moving;
- stability against overturning (considering kinetic energy);
- mass and stability (potential energy of elements which can move under the effect of gravity);
- mass and velocity (kinetic energy of elements in controlled or uncontrolled motion);
- acceleration/deceleration;
- inadequate mechanical strength, which can generate hazardous breakages or bursts;

- potential energy of elastic elements (springs), or of liquids or gases under pressure or vacuum;
- working environment.

4.3 Electrical hazard This hazard can cause injury or death from electric shock, or burn; these can be caused by:

- contact of persons with:
  - live parts, i.e. conductors or conductive parts intended to be energized in normal operation (direct contact);
  - parts which have become live under fault conditions, especially as a result of an insulation failure (indirect contact);
- approach of persons to live parts, especially in the range of high voltage;
- insulation not suitable for reasonably foreseeable conditions of use;
- electrostatic phenomena such as contact of persons with charged parts;
- thermal radiation;
- phenomena such as projection of molten particles or chemical effects from short-circuits or overloads.

It can also cause falls of persons (or of objects dropped by persons) as a result of the surprise caused by electric shock.

4.4 Thermal hazard Thermal hazard can result in:

- burns and scalds from contact with objects or materials with an extreme temperature, flames or explosions and radiation from heat sources;
- health-damaging effects generated by hot or cold work environment.

4.5 Hazard generated by noise Noise can result in:

- permanent hearing loss;
- tinnitus;
- tiredness, stress;
- other effects such as loss of balance, loss of awareness;
- impairment of speech communication or of the perception of acoustic signals.

4.6 Hazards generated by vibration Vibration can be transmitted to the whole body (use of mobile equipment) and particularly to hands and arms (use of hand-held and hand-guided machines).

The most severe vibration (or less severe vibration over a long time) may generate serious disorders (low-back morbidity and trauma of the spine), severe discomfort resulting from whole-body vibration and vascular disorders, e.g. white-finger disease, neurological, osteo-articular disorders, resulting from hand-arm vibration.

4.7 Hazards generated by radiation These hazards, which can have immediate effects (e.g. burns) or long-term effects (e.g. genetic mutations), are produced by a variety of sources and can be generated by non-ionizing or ionizing radiation:

- electromagnetic fields (e.g. in the low frequency, radio frequency, micro-wave ranges);
- infra-red light, visible light and ultra-violet light;
- laser radiation;
- X and γ rays;
- α, β rays, electron or ion beams, neutrons.

4.8 Hazards generated by materials and substances Materials and substances processed, used, produced or exhausted by machinery, and materials used to construct machinery can generate several different hazards:

- hazards resulting from ingestion, contact with the skin, eyes and mucous membranes or inhalation of fluids, gases, mists, fumes, fibres, dusts or aerosols, having, e.g. a harmful, toxic, corrosive, teratogenic, carcinogenic, mutagenic, irritant or sensitizing effect;
- fire and explosion hazards;
- biological (e.g. mould) and micro-biological (viral or bacterial) hazards.

4.9 Hazards generated by neglecting ergonomic principles in machine design Mismatch of machinery with human characteristics and abilities can show itself by:

- physiological effects (e.g. musculo-skeletal disorders) resulting, e.g. from unhealthy postures, excessive or repetitive efforts;
- psycho-physiological effects generated by, e.g. mental overload or underload, or stress, arising from the operation, supervision or maintenance of a machine within the limits of its intended use;
- human errors.

4.10 Slipping, tripping and falling hazards Neglecting the surface of the floorings and access means may result in injuries from slips, trips or falls.

4.11 Hazard combinations Some individual hazards which seem to be minor can, when combined with each other, be equivalent to a significant hazard.

4.12 Hazards associated with the environment in which the machine is used Where a machine is designed to operate under environmental conditions which can result in hazards (e.g. temperature, wind, snow, lightning) these hazards shall be taken into account.

5 Strategy for risk reduction

5.1 General provisions

5.1.1 It is assumed that, when present on machinery, a hazard will sooner or later lead to harm if no protective measure(s) is (are) taken.

5.1.2 Protective measures are a combination of the measures taken by the designer and the user (see figure 1). Measures which can be incorporated at the design stage

are preferable to and generally more effective than those which are implemented by the user.

5.1.3 Taking into account the experience of users of similar machines and whenever practicable, an exchange of information with the potential users, the designer shall take the following actions, in the order indicated below (see figure 2):

- specify the limits and the intended use of the machine (see **5.2**);
- identify the hazards and associated hazardous situations (see clause **4** and **5.3**);
- estimate the risk, for each identified hazard and hazardous situation (see **5.3**);
- evaluate the risk and take decisions about the need for risk reduction (see **5.3**);
- eliminate the hazard or reduce the risk associated with the hazard by protective measures (see **5.4** and **5.5**);

The first four above indents are related to risk assessment, on which detailed information can be found in **JIS B 9702**.

5.1.4 The objective to be met is the greatest risk reduction taking into account the four factors below. The strategy defined above is represented by the flowchart in figure 2. The process is iterative and several successive applications may be necessary to reduce the risk, making the best use of available technology.

In carrying out this process, it is necessary to take into account in the following order of preference;

- the safety of the machine during all the phases of its lifecycle;
- the ability of the machine to perform its function;
- the usability of the machine;
- the manufacturing, operational and dismantling costs of the machine.

NOTES 1 The ideal application of these principles requires knowledge of the use of the machine, the accident history and health records, available risk reduction techniques, the legal framework in which the machine is to be used.

2 A machine design which is acceptable at a particular time may no longer be justifiable when technological development allows the design of an equivalent machine with lower risk.

5.1.5 For the continued safe operation of a machine, it is important that the protective measures allow its easy use and do not hinder its "intended use". Not doing this could lead to protective measures being bypassed in order to achieve maximum utility of the machine.

5.1.6 If standardized (or other suitable) measurement methods exist for an emission, they should be used, in conjunction with existing machinery or prototypes, to determine emission values and comparative emission data.

This makes it possible for the designer:

- to estimate the risk associated with the emissions;
- to evaluate the effectiveness of the protective measures implemented at the design stage;

- to provide potential buyers with quantitative information on emissions in the technical documentation;
- to provide users with quantitative information on emissions in the information for use.

Hazards other than emissions that are described by measurable parameters can be dealt with in a similar manner.

5.2 Specification of the limits of the machine The design of the machine begins with the specification of its limits (see also **JIS B 9702**:2000, clause **5**);

- use limits:
  - the "intended use" of the machine, including the different machine operating modes, phases of use and the different intervention procedures for the operators and
  - the reasonably foreseeable misuse of the machine;
- space limits :
  (e.g. range of movement, space requirements for installation and maintenance of the machine, "operator-machine" interface, "machine-power supply" interface);
- time limits :
  the foreseeable "life limit" of the machine and/or of some of its components (e.g. tools, wear parts, electrical components), taking into account its "intended use".

5.3 Hazard identification, risk estimation and risk evaluation Having identified the various hazards that can be generated by the machine (permanent hazards and those which can appear unexpectedly: see **3.6** and clause **4**), the designer shall estimate the risk for each hazard, as far as possible on the basis of quantifiable factors, and finally decide if risk reduction (see **5.4**) is required as a result of the risk evaluation. For this purpose, the designer shall take into account the different operating modes and intervention procedures, in particular:

a) human interaction during the whole lifecycle of the machine, as described below:
   1) construction;
   2) transport, assembly and installation;
   3) commissioning;
   4) use:
      - setting, teaching/programing or process changeover;
      - operation;
      - cleaning;
      - fault finding;
      - maintenance;
   5) de-commissioning, dismantling and, as far as safety is concerned, disposal;
b) possible states of the machine:
   1) the machine performs the intended function (the machine operates normally);

2) the machine does not perform the intended function (i.e. it malfunctions) due to a variety of reasons including:

- variation of a property or of a dimension of the processed material or of the workpiece;
- failure of one (or more) of its component parts or services;
- external disturbances (e.g. shocks, vibration, electromagnetic interference);
- design error or deficiency (e.g. software errors);
- disturbance of its power supply;
- surrounding conditions (e.g. damaged floor surfaces);

c) unintended behaviour of the operator or reasonably foreseeable misuse of the machine, e.g.:

- loss of control of the machine by the operator (especially for hand-held or mobile machines);
- reflex behaviour of a person in case of malfunction, incident or failure during the use of the machine;
- behaviour resulting from lack of concentration or carelessness;
- behaviour resulting from taking the "line of least resistance" in carrying out a task;
- behaviour resulting from pressures to keep the machine running in all circumstances;
- behaviour of certain persons (e.g. children, disabled persons).

Information : Taking the "line of least resistance" refers to "shortcut reaction" or "omission of behaviour" of Gestalt.

Risk estimation and evaluation have to be applied after each of the three steps of risk reduction defined in **5.4** and illustrated in figure 2.

When carrying out a risk assessment, the risk from the most likely severity of the harm that is likely to occur from each identified hazard shall be considered, but the highest foreseeable severity shall also be taken into account, even if the probability of such an occurrence is not high.

5.4 Elimination of hazards or reduction of risk by protective measures This objective may be met by removing the hazards or by reducing, separately or simultaneously, each of the two elements which determine the risk:

a) severity of harm from the hazard under consideration;

b) probability of occurrence of that harm.

All protective measures intended to reach this objective shall be applied according to the following sequence, referred to as the "3-step method" (see also figures 1 and 2) :

- inherently safe design measures (see **JIS B 9700-2**:2004, clause **4**);

NOTE : This stage is the only one at which hazards can be eliminated, thus avoiding the need for additional protective measures such as safeguarding or complementary protective measures.

- safeguarding and possibly complementary protective measures (see **JIS B 9700-2**:2004, clause **5**);
- information for use about the residual risk (see **JIS B 9700-2**:2004, clause **6**)

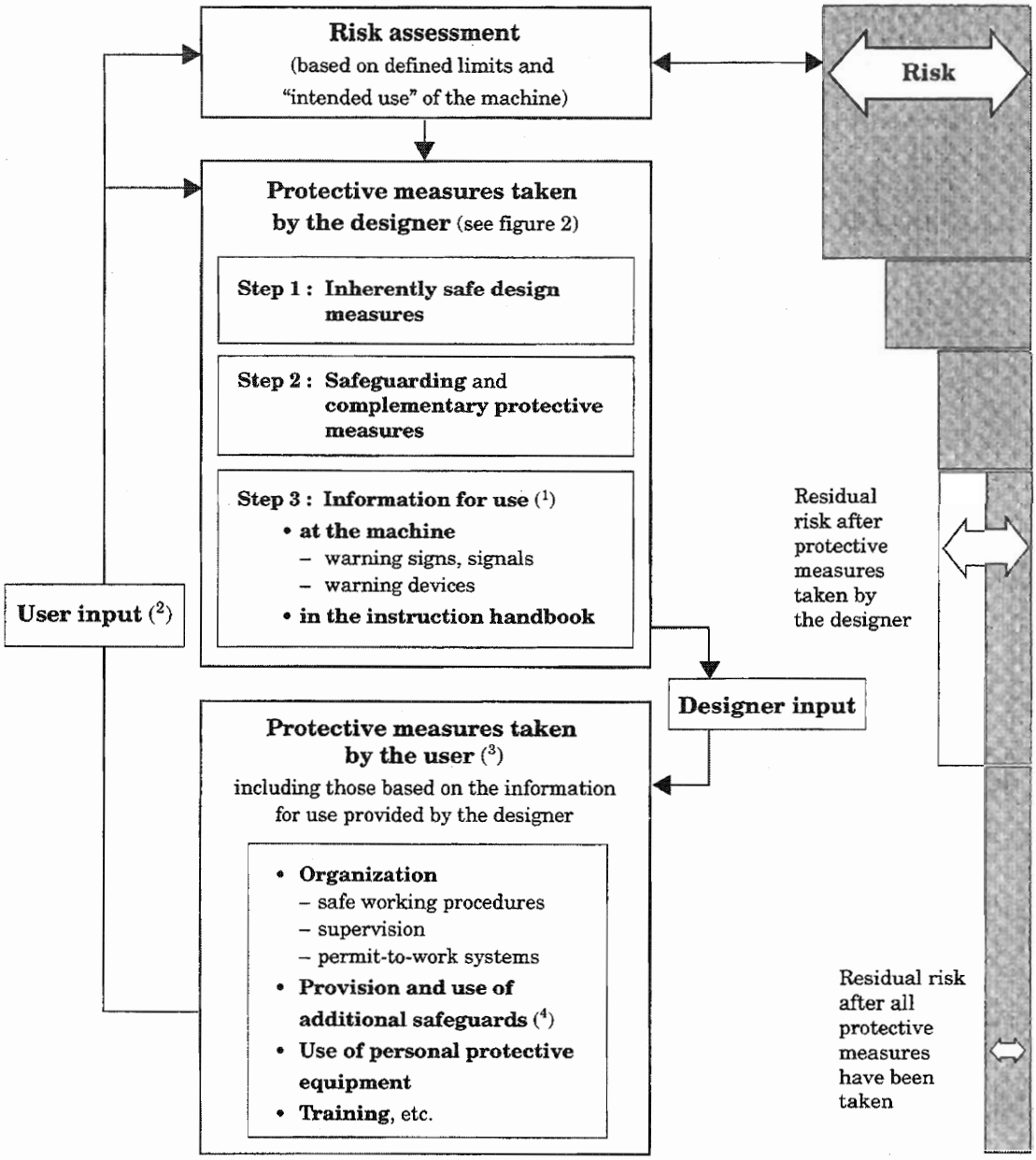
Information for use shall not be a substitute for the correct application of inherently safe design measures or safeguarding or complementary protective measures.

Adequate protective measures associated with each of the operating modes and intervention procedures (see **5.3**) prevent operators from being induced to use hazardous intervention techniques in case of technical difficulties.

5.5 Achievement of risk reduction objectives The iterative risk reduction process according to **5.4** and figure 2 can be concluded after achievement of adequate risk reduction and, if applicable, a favourable outcome of risk comparison (see **JIS B 9702**:2000, **8.3**).

Adequate risk reduction can be considered achieved when one is able to give a positive answer to each of the following questions:

- have all operating conditions and all intervention procedures been taken into account?
- has the method stated in **5.4** been applied?
- have hazards been eliminated or risks from hazards been reduced to the lowest practicable level?
- is it certain that the measures taken do not generate new hazards?
- are the users sufficiently informed and warned about the residual risks?
- is it certain that the operator's working conditions are not jeopardized by the protective measures taken?
- are the protective measures taken compatible with each other?
- has sufficient consideration been given to the consequences that can arise from the use of a machine designed for professional / industrial use when it is used in a non-professional / non-industrial context?
- is it certain that the measures taken do not excessively reduce the ability of the machine to perform its function?



Notes (1) Providing proper information for use is part of the designer's contribution to risk reduction, but the protective measures concerned are only effective when implemented by the user.

(2) The user input is that information received by the designer from either the user community regarding the "intended use" of the machine in general or that which is received from a specific user.

(3) There is no hierarchy between the various protective measures taken by the user. These protective measures are outside the scope of this Standard.

(4) Those protective measures required due to specific process(es) not envisaged in the "intended use" of the machine or to specific conditions for installation that cannot controlled by the designer.

Figure 1 Risk reduction process from the point of view of the designer

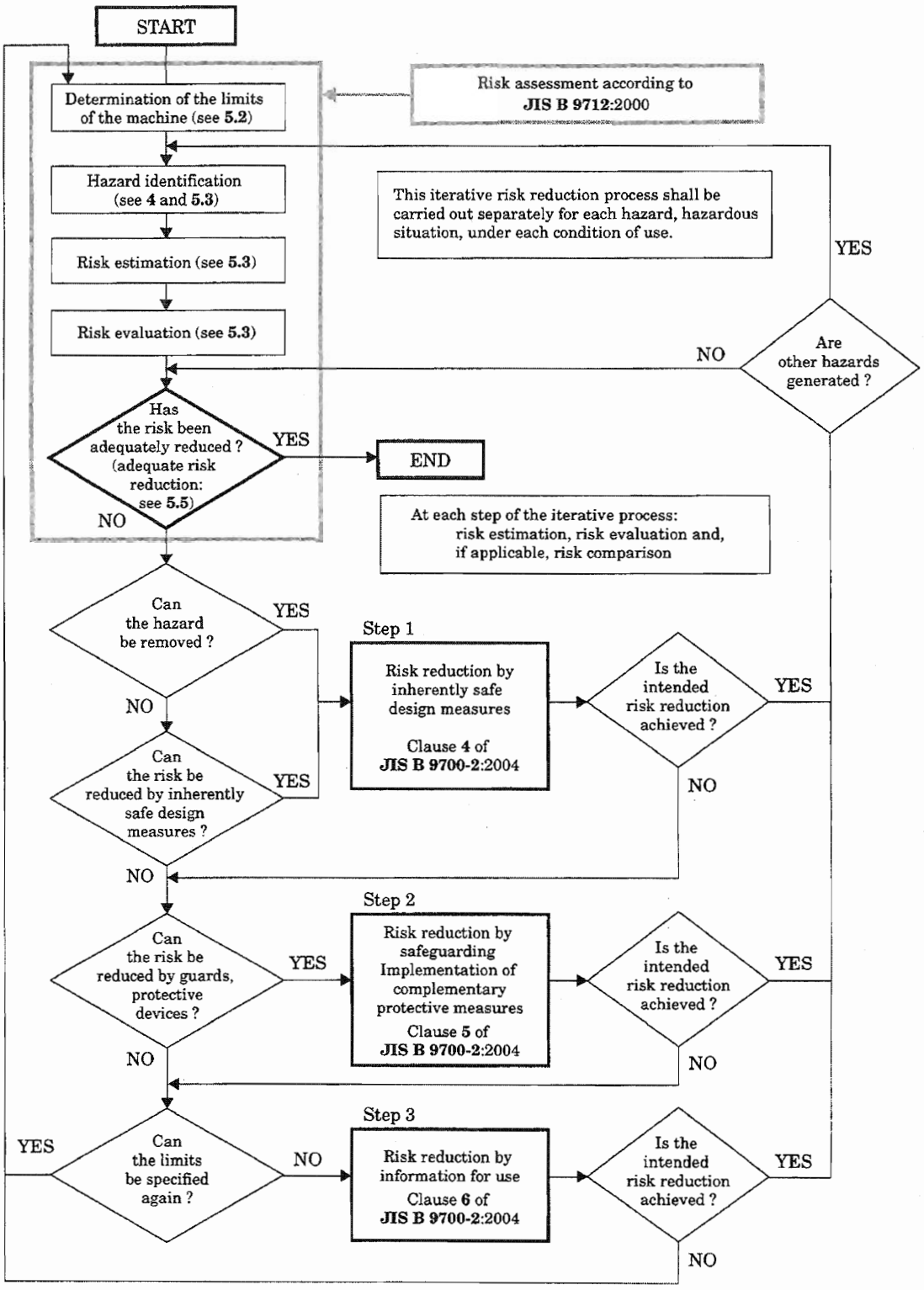
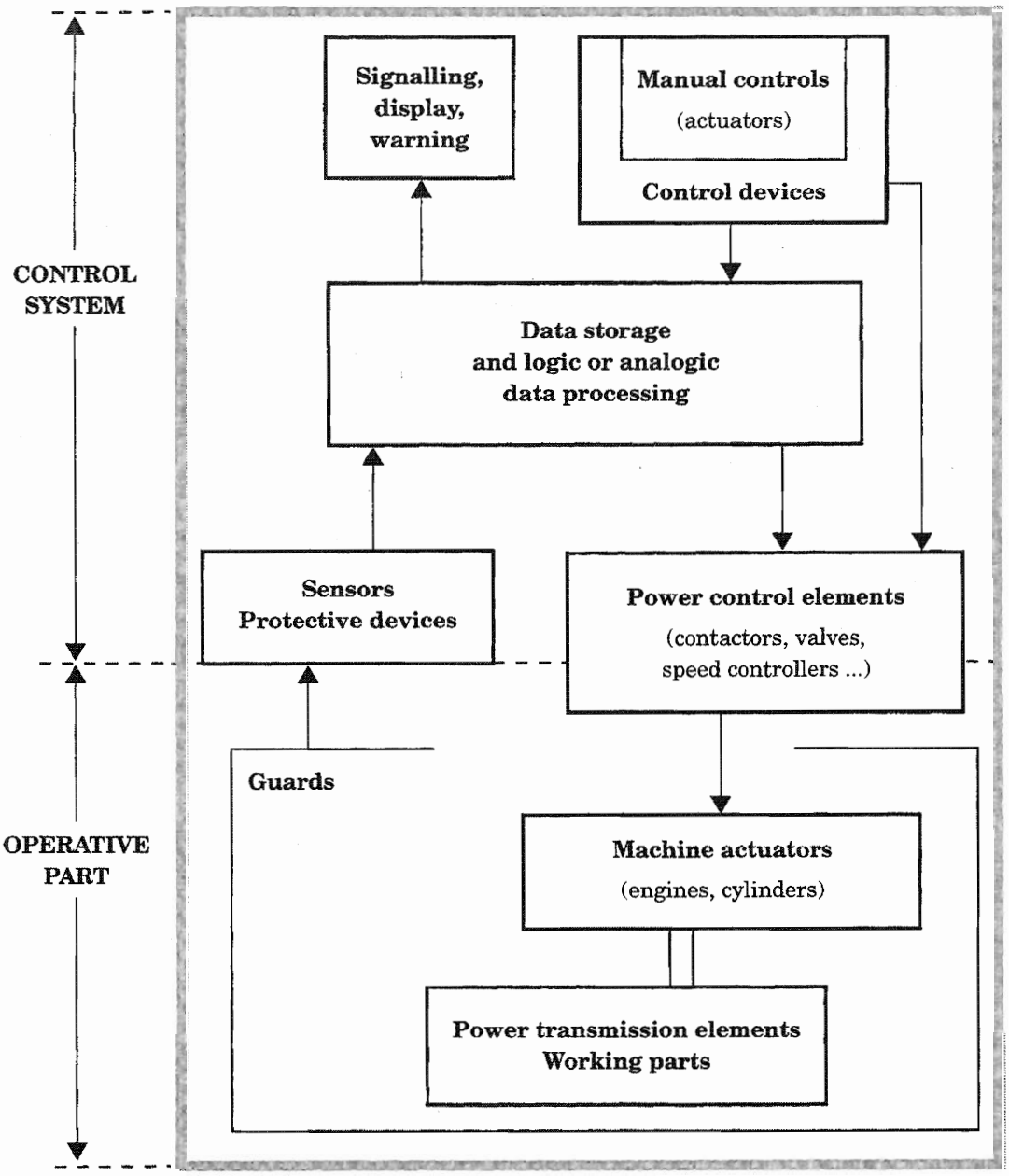


Figure 2 Schematic representation of the iterative 3-step method for the risk reduction process

Annex A (informative) Schematic representation of a machine

This annex supplements matters to the text, and does not constitute part of the provisions.



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Errata for JIS (English edition) are printed in *Standardization Journal*, published monthly by the Japanese Standards Association, and also provided to subscribers of JIS (English edition) in *Monthly Information*.

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